An Overview of Marine Science and Technology in the Asia-Pacific Region

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ABSTRACT

Across the vast Asia-Pacific region the various nations, either individually or as part of regional programs, are engaged in marine science and technology activities that run the gamut from satellite remote sensing to deep-sea submersibles. Japan plays a leading role in these activities, with a sizable investment from both industry and government in marine S&T. JAMSTEC's Long-Term Deep Seafloor Observatory is an example of state-of-the art S&T employed by Japan to observe the seafloor. China and S. Korea are likely to challenge Japan's leadership in marine S&T, as both countries have extensive and growing capabilities in this area. The use of robotics for deep sea exploration is an area of considerable interest to China. An example is provided by the remotely operated vehicle system developed to retrieve sunken objects. At the other end of the spectrum, China is applying satellite remote sensing to monitor the delta growth at the mouth of the Yellow River. Russia, in spite of the greatly reduced level of S&T in recent years, still possesses immense scientific and technological expertise and capability, and marine S&T is still being actively pursued in many areas. The Large Thermostratified Test Tank of Russia's Institute of Applied Physics is a unique system designed to study processes in the upper layer of the ocean. Geographically tiny Singapore, already a manufacturing powerhouse in the Asia-Pacific region, has made major commitments to R&D, including the marine sector. A recent accomplishment of the National University of Singapore is a "Pop-up Ambient Noise Data Acquisition System," a submerged data acquisition system for collecting acoustic data that provides an effective and cheap method to measure ambient noise. India is making great efforts to exploit its very rich and extensive marine environment, while trying to mitigate the degradation caused to its coastline by its immense population. India, a land of paradoxes, has also deployed an indigenously-built ocean-monitoring satellite. Coastal erosion is also one of Malaysia's priorities, particularly for the University of Technology of Malaysia. They have developed an interesting potential solution for coastal and riverside area erosion, the "Sine-Slab" System, a patented pre-cast concrete product designed to accommodate nature's forces. Apart from the individual efforts of the various countries in this area, there are a number of international projects that foster collaboration on regional and global scales, particularly prominent among these are the WESTPAC-supported collaborations.

INTRODUCTION

The depth and diversity of marine science and engineering across the Asia-Pacific region is truly immense. Using technology covering the gamut from satellite remote sensing to deep-sea submersibles, the ocean and coastal marine environments are being monitored, explored, and exploited at an increasing pace and level of sophistication from Harbin in northern China to New Zealand, and from Kamchatka, Russia to the Arabian Sea. The significance of the ocean/marine environment for their economy, social well-being, and security is certainly not lost on the Asia-Pacific nations. Most of these nations are either entirely or largely surrounded by the sea and/or have extensive shorelines. Moreover, in many of them there is a relative sparsity of arable land and other resources. China, for example, with the third largest area in the world, and rich in land minerals and fresh water resources, is nevertheless significantly below the world per capita average in these and other resources. In Korea, less than 20% of the land is arable and land natural resources are sparse. Similarly, Japan's arable land is less than 13% of the total and land

resources are minimal. Hence, the destinies of many of the Asia-Pacific peoples are inextricably linked to the sea.

The particular areas of marine S&T emphasized in each country are clearly dependent on the special circumstances of the country, but certain general areas are common. Included among these are: marine science, aquaculture and fisheries, mineral exploitation, port and harbor facilities, defense, coastal zone development and management, and so forth. In spite of the recent economic downtrends, the Asia-Pacific nations are committing vast resources and capital to these areas. This trend is likely to continue, in fact to accelerate in the future. Indeed, in view of the recognition of the increasingly vital role of the coastal and ocean environments to mankind, one can expect marine issues to be one of the dominant focuses of S&T in the 21st century.

The application of marine S&T to the coastal zone is a particularly significant focus of many of the Asia-Pacific nations. Although it comprises only a narrow strip of space extending a few tens of kms on either side of the shore line, the coastal zone has a substantial impact on mankind. It occupies less than 10% of the ocean surface and 1% of its volume, but accounts for nearly a quarter of oceanic biological production, which in turn supplies 90% of the world's fish catch. The coastal zone is home to approximately 60% of the human population and two-thirds of the mega-cities. concomitantly, more than 90% of the pollutants generated by their economic activities end up in the coastal zone.

It is clear that the extent and diversity of marine science and technology in this vast geographic region precludes anything but a cursory glimpse of these activities in a single paper. Attempting even such a task is challenging, if not presumptuous. In what follows, particular examples of interesting or innovative marine S&T are drawn from across the region. Clearly, not all countries could be represented, while some countries, e.g., Japan, China, and S. Korea, have received relatively large coverage. Several of the omitted countries are engaged in noteworthy activities in particular areas of marine S&T, but, with the exception of Australia, and, to a lesser extent, New Zealand, the scope and infrastructure of their marine S&T does not approach that of Japan, China, Russia, or S. Korea. In some cases, the brief coverage runs the risk of "condemning by faint praise." All these caveats not withstanding, it is hoped the following will provide a sense of the broad range and types of marine affairs across the Asia-Pacific region.

OVERVIEW OF MARINE S&T IN SEVERAL COUNTRIES

Japan

Japan plays a leading role in marine S&T in the Asia-Pacific Region, and, barring unforeseen significant changes, is likely to continue in this role for several decades to come. Japan is the world's second largest economy, with a Gross Domestic Product (GDP) about 60% of the USA's, five times that of the United Kingdom, and nearly equal to that of Germany, France and Italy combined. Its spending on research and development (R&D) is also quite impressive. In FY1996, government and industry in Japan spent roughly $106 billion on R&D, about 2.9% of its GDP. Notably, the government share of this cost is relatively small (23%), as is its expenditure for defense R&D (only 4% of the national budget). Moreover, Japan is unique among the G7 countries in significantly increasing spending on public science. The government agency with primary responsibility for S&T funding is the Science and Technology Agency (STA). In the area of marine R&D government spending in 1998 was approximately 80 billion Yen ($666 million, at $1 equals 120 Yen). This figure does not, of course, adequately represent Japan's investment in marine S&T, since industry and universities also play a significant role.

Japan's limited land resources, large population, and extensive marine exclusive economic zone (EEZ) have necessitated an aggressive and innovative pursuit of ocean space utilization. Japanese industry plays a significant role in the development of marine engineering. Indeed, a strong industrial base has been one of the key factors contributing to Japan's striking accomplishments in marine S&T. This has many manifestations, including land reclamation, off-shore floating structures,

sea-crossing bridges and underwater tunnels, ocean wave energy conversion devices (e.g., JAMSTEC's "Mighty Whale"), and so forth. Developments surrounding the use of large-scale floating structures ("Mega floats") are particularly well known, as they have attracted widespread attention among the public and in the press. Apart from ameliorating Japan's chronic land shortage problem, Mega floats have been proposed as a potential solution to the politically sensitive issue of stationing U.S. forces in Okinawa.

Many organizations in Japan are actively involved in ocean research and technology. Prominent among them are the Japan Marine Science and Technology Center (JAMSTEC**),** the National Space Development Agency of Japan (NASDA); the Japan Meteorological Agency (JMA); ministries devoted to trade, industry, and fisheries; several universities; and industry. Key universities are: The University of Tokyo (Ocean Research Institute; Department of Earth and Planetary Physics; Institute of Industrial Science); Kyushu University (Research Institute for Applied Mechanics); Tokai University; Hokkaido University; Tohoku University; Kyoto University; Ehime University; Kagoshima University; University of Ryukyus; and others.

JAMSTEC, a semi-autonomous entity, is Japan's national center for marine S&T and one of Japan's major players in this area. From STA's 1998 budget, a sizable portion ($200 million) was allocated to JAMSTEC. Its activities are organized into three broad areas: Deep Sea Research, Ocean Research, particularly the ocean's effect on global environmental changes, and Coastal Studies. It has extensive and impressive capabilities in these areas, including manned submersibles (*Shinkai* 2000 and *Shinkai* 6500), unmanned deep submersibles (*Kaiko* and others), and state-of-the-art research vessels, including *Mirai* (the "future"), *Yokosuka*, and *Kairei* ("trench"), an impressive acoustic tomography system, and so forth. The remotely operated vehicle (ROV) *Kaiko* is particularly noteworthy, having descended from its support ship, Yokosuka, to the bottom of the Mariana Trench (10,911 meters). JAMSTEC's program in deep sea submersibles is well suited to complement its program in deep sea earthquake activity, as seen in the next paragraph. ROVs and other submersibles also have great promise for the exploitation of seabed minerals, the laying and maintenance of underwater cables, and other uses.

JAMSTEC is also a key player in Japan's deep commitment to monitor and understand volcanic and seismic activity, a commitment deriving largely from Japan's perennial problem with earthquakes and Tsunamis. Figure 1 shows JAMSTEC's Long-Term Deep Seafloor Observatory, deployed on the seafloor at a depth of 3,500 meters between Cape Muroto and the Nankai Trough to explore deep sea earthquake activity. This is an area of active crustal deformation where the Philippine Sea Plate is subducting beneath the Eurasian Plate, resulting in the occurrence of large earthquakes. The system commenced operation in April 1997, providing vital information in an area that was hitherto a "blind spot" in the observational coverage of submarine earthquakes. The goal of the system is to enhance the understanding of earthquake occurrences by providing real-time monitoring of the deep-sea environment, particularly changes associated with earthquakes and Tsunamis. As shown schematically in the figure, an optical fiber cable will be laid from the Muroto Land Station to a seafloor observatory about 100 km from land (center of figure). The seafloor observatory equipment will include current meters (ADCP), conductivity, temperature, and density sensors (CTD), geo-thermometers, hydrophones, and a color video camera (for monitoring of biological communities). A seismometer and tsunami sensor will also be connected to the cable at a distance of 50 km from land. The cable will transmit the data in real time, via the land station, to JAMSTEC and the Japanese Meteorological Agency. A similarly equipped Buoy-Satellite Observatory, located 200 km from land (right side), will transmit data monthly to a marine satellite by means of pop-up telemetry buoys. Surrounding this observatory are pop-up seismometers. These measurements are supplemented with rock samples and gamma ray measurements from submarine surveys obtained from the *Shinkai* submersibles, and also multi-channel seismic profiles from the R/V *Kairei*.

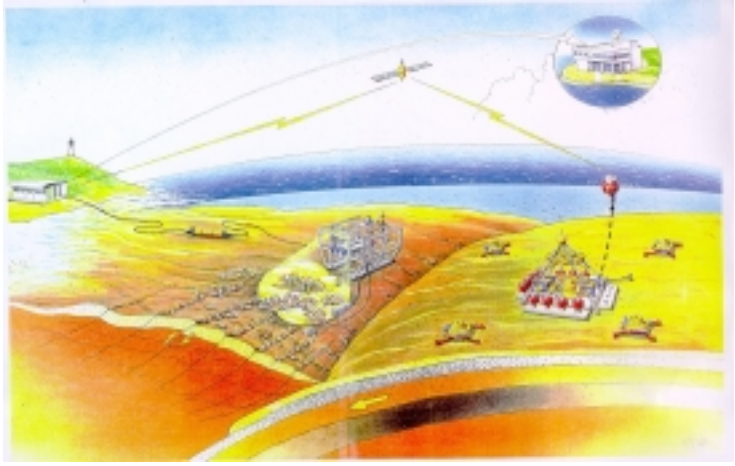

Figure 1 JAMSTEC's Long-Term Deep Seafloor Observatory

The National Space Development Agency of Japan (NASDA) also plays a prominent role in Japan's marine S&T activities. It is the primary agency for satellite development activities and technology and data utilization. It is at the cutting edge of satellite remote sensing technology and research and has many notable accomplishments in this field. Its short-lived “advanced earth observation satellite” (ADEOS) provided invaluable data on ocean color and sea surface temperatures. The launch of ADEOS-11, originally planned for 1999, is now scheduled for late 2001; it will include sensors to monitor global climate change, meteorology, and fisheries.

In November 1997, NASDA launched another satellite, as part of the Tropical Rainfall Measuring Mission (TRMM), a joint project between Japan (NASDA) and the USA (NASA). TRMM includes the first space-based precipitation radar (PR), among other sensors. The PR can observe the three-dimensional structure of rainfall over the tropics, and hence is expected to make an important contribution to understanding the global climate.

China

"China sleeps; when she wakes, she will shake the world." (Napoleon)

Overview

China is awake, and appears to be on the fast track to superpower status. At present, China is the fastest growing economy in the world, and the Chinese government has made a commitment to rapidly enhance China's capabilities and world standing in science and technology. This includes a growing investment in research, reforming the Chinese Academy of Sciences, encouraging the return of expatriate scientists and engineers, and strengthening and enhancing international ties.

Following the adoption of national reform and openness policies launched by Deng Xiaoping at the Third Party Plenum in 1978, a series of major programs and activities were initiated with the goal of providing a firm basis to the economy by strengthening the country's science and technology. The primary goal and central task of S&T in China is economic development and social improvement; hence, top priority is given to research and development (R&D) projects that are likely to further this objective. Particularly significant among these activities is the high-tech research and development program, the so-called "863 Program" launched in March 1986 (hence the name), which includes marine technology.

At the present time more than half a million scientists and engineers are employed in R&D, and they are being joined each year by thousands of excellent western-trained scientists returning home. Moreover, they are assured ready access to S&T by over 6000 libraries and information centers with scientific databases, as well as thousands of other scientific and technical service providers. World-class research is being done at many Chinese institutions, including the approximately two dozen "Key Laboratories" created by the government about a decade ago. In all sectors of S&T, competition appears to be alive and well.

Marine Science and Technology in China

Sixty percent of China's output derives from its coastal provinces, which are home to 40% of its population of more than 1.2 billion. China's land natural resources per capita are lower than the world's average; however, its maritime territory is large. Its mainland coastline exceeds 18,000 km; its territorial waters include more than 5,000 islands, each with an area of more than 500 square meters; and the islands' coastlines total more than 14,000 km. China also exercises sovereignty and jurisdiction over large continental shelves and exclusive economic zones (EEZs), as defined by the UN Convention on the Law of the Sea. As a result, China devotes considerable effort to acquiring, developing, and improving marine science and technological expertise and equipment. Although recent decades have seen acceleration in these efforts, China's interest is ancient. In the area of acquaculture, for example, it is at least 3,000 years old: the first document on common carp monoculture techniques was written by Fan Li in 473 BC.

China is a major participant in international maritime affairs, including cooperative surveys, researches, and exchanges, and many of the well-known international expeditions. Among the latter projects are those concerning the deltas of the Yangtze and Yellow rivers, the Kuroshio front, air-sea interaction, and the bio-diversity of Hainan Island. During the Kuroshio survey, jointly conducted by China and Japan from 1986 to 1992, more than 100 field operations were carried out, resulting in valuable data for understanding the origin and movements of the Kuroshio, as well as the factors affecting the fishing grounds of the Western Pacific.

Ocean S&T Institutes in China

China's multidisciplinary marine S&T setup is large and diverse, including more than 109 research institutions and 13,000 research personnel in the area of oceanographic research and technology. Apart from the universities, much of the marine science and technology in China is conducted by institutes belonging to two large, "half-ministry-level" government agencies: the Chinese Academy of Sciences (CAS), usually denoted by its Latin name, *Academia Sinica*, and The State Oceanic Administration (SOA), likened by some to NOAA. The China State Shipbuilding Corporation (CSSC) also supports activity in this area. The Harbin Engineering University, for example, is under CSSC.

China’s marine S&T activities run the gamut from **deep sea exploration** to satellite remote sensing. In the former area, which includes submersibles, autonomous vehicles, and intelligent robots, the Harbin Engineering University (HEU) has been an essential player. They jointly developed a 6,000-m class, untethered, underwater robot, that in 1997 successfully conducted a sea-bottom survey of metallic clusters at a depth of 5,217 meters in the Western Pacific Ocean. Another of their developments is an ROV system designed to retrieve sunken objects. The system consists of an underwater vehicle and a surface mother support ship. It has object-detection and refloatation functions, and can be operated in two maneuvering modes: remote control via cable, and manned control.

Figure 2 The ROV designed by China's HEU to retrieve sunken objects

The underwater vehicle, shown in Figure 2, is 8 meters long, 3.35 meters high, and weighs 16 tons. It is equipped with an integrated maneuvering control system, cable control system, navigation system, propulsion system, detection & observation system, and an underwater operating system. During manned operations, the position of the submerged object is detected by means of an image sonar, and the crewman navigates the vehicle to the vicinity of the object. With the aid of underwater television and a large-diameter observing window, the object can be found and, after adjusting the stance of the vehicle, the mechanical arm is extended and its hand used to grasp and retrieve the object. During remote operation of the vehicle, all signals and information are fed back through a 6mm-diameter, zero-buoyancy photic cable. Detection, navigation and the robotic arm's mission are then remotely executed by an operator in the mother ship. Several successful trials of the system in both operating modes have been conducted by HEU.

In the area of **satellite remote sensing** Chinese interests and capabilities span the full range of ocean remote sensing practice and involve many of its marine S&T institutes. Prominent among the latter, are the Institute of Remote Sensing of the Ocean University of Qingdao, the Remote Sensing Satellite Ground Station (CRSGS) and the Institute of Remote Sensing Applications (IRSA). These and other institutes are first-rate, and are performing exceedingly impressive work in a wide range of remote sensing subjects. In a few important areas, especially the uses of multispectral imagers, infrared imagers, and the analysis and application of synthetic aperture radar (SAR) data, they are close to the global state-of-the-art.

The Chinese have ground stations to receive most international satellite data, including SeaWifs. In addition, they have been active in their own satellite development program. Over the last four decades China has launched 37 satellites and has established exchanges and collaboration with more than 70 countries in the field of space technology. Several of these satellites were devoted to remote sensing. At present, at least three satellites are in various stages of planning: a color/temperature system (COCTS); an altimeter system; and a SAR system.

Underwater acoustics is an important discipline in China and is investigated in a number of Chinese institutions, including the Institute of Acoustics, CAS (IAAS), the Northwestern Polytechnical University (Xi'an), and the Harbin Engineering University. The IAAS is presently collaborating with several U.S. universities in an ONR-sponsored study of shallow-water acoustics. As part of this effort, a pilot experiment was conducted in 1996 in the Yellow Sea. Since then, collaboration has expanded to include several other Asia-Pacific nations, and there are plans for a major international experiment (ASIAEX) in the China seas for the year 2001.

S. Korea

The Korean economy is the seventeenth largest in the world, and although S. Korea has recently experienced economic hardship, the new government of the Republic of Korea envisages Korea's future as a "technology-based industrial economy." This is reflected in the strengthening of the role of the Ministry of Science and Technology (MOST) by enhancing its rank relative to

the other ministries. In 1998 the expenditure on R&D at government supported institutes was approximately $2.5 billion. The already considerable government investment in R&D is expanding from 3.7% of the total government budget to 5% by the year 2002.

MOST has the responsibility for overseeing and coordinating S&T policy in Korea. It does this, in part, by means of 20 Government Research Institutes (GRIs) concerned with R&D. One of the few GRIs involved with marine matters is the Korean Institute of Machinery & Metals (KIMM), which includes the Korean Research Institute of Ships & Ocean Engineering (KRISO). Until recently, the Korean Ocean Research & Development Institute (KORDI) was one of the GRIs; it is now under the Ministry of Maritime Affairs and Fisheries (MOMAF).

Korea's commitment to marine S&T is strongly influenced by its geography, limited arable land, and high population density. In the area of marine technology, it is paying particular attention to shipbuilding and ocean engineering, offshore drilling, deep seabed mining, and fisheries. Ocean science priorities include: understanding ocean processes, particularly those in the Yellow Sea and the Japan/East Sea; understanding and mitigating the degradations of the coastal environment and its impact upon Korean society; understanding the impact of large scale coastal development; and so forth.

KORDI is involved in many aspects of marine S&T, including marine chemistry, biological oceanography, marine geology and geophysics, Polar research, deep sea resources research, coastal and harbor engineering, and oceanographic data and instrumentation. Among KORDI's repertoire of research tools are the multi-purpose 1,422 ton research vessel "Onnuri" and the submersible support vessel "Eardo." Interestingly, KORDI (The Polar Research Center) also maintains the "King Sejong" Antarctic Station on King George Island where it conducts year-round observations and environmental monitoring.

KORDI closely collaborates with several Korean universities, especially Sung Kyun Kwan University and Hanyang University. The caliber of the Korean researchers at these, and other, Korean universities is quite impressive, as are the extensive ongoing efforts in coastal and ocean dynamics. Among the many interesting things being developed at Sung Kyun Kwan University, for example, is a high-resolution three-dimensional numerical model of tides in the Yellow Sea. This is an important step in developing operational marine forecasting systems for the region. Accurate modeling and prediction of tidal behavior, particularly along continental shelves and coastal areas, has several applications, including assessing the effects of environmental pollution, expediting search and rescue operations, and predicting the extent of damage to coastal areas and equipment.

Seoul National University (SNU), particularly the Research Institute of Oceanography, is a dominant player in Korean ocean science. It is leading the Korean participation in the CREAMS Project (Circulation Research of the East Asian Marginal Seas). CREAMS is an international collaboration between Korea, Japan, and Russia, initiated in 1993, to investigate the Japan/East Sea water mass structure and circulation. A major new development has been the involvement of U.S. researchers, supported by a 5-year ONR program, the Japan/East Sea (JES) Project, related to CREAMS.

Several universities in S. Korea are actively involved in various aspect of satellite remote sensing of the ocean. Several AVHRR stations are located in S. Korea, with fisheries being a primary application. They are also receiving most of the other satellite data, including Landsat, Radarsat, and SeaWifs. The remote sensing of ocean color is the focus of much research in Korean institutes. The availability of greatly improved satellite-borne optical sensors in recent years has given a strong boost to such efforts. Apart from its role in providing insight into the global ocean-atmosphere exchanges (especially the Carbon Cycle), ocean color has several other important applications. Because phytoplankton drift with ocean currents, long-term observations of phytoplankton, using ocean color, can provide information on ocean circulation, the course of river discharges, marine pollution, and other parameters. Ocean color imagery can also be used to guide fishing fleets to biologically rich areas. In the study of coastal areas, ocean color

measurements provide information on coastal erosion, sediment transfer, biological productivity, and coastal-zone water dynamics (eddies, currents). Ocean color, and ocean optical properties in general, are also of great significance to the Navy, particularly in littoral environments.

Russia

In spite of the greatly reduced level of S&T in recent years, Russia it is still a country with immense scientific and technological expertise, experience, and capability, and marine S&T is still being actively pursued in many areas. Particularly noteworthy are the efforts in the areas of submersibles and underwater acoustics. Russia's experience with **deep sea submersibles** is formidable. For several decades a number of Russian institutions have been engaged in the development and use of ROVs and autonomous underwater vehicles (AUVs). The Institute of Marine Technology Problems (IMTP), of the Far Eastern Branch of the Russian Academy of Sciences, and the Far Eastern State Technical University (FESTU) are particularly prominent among them. FESTU has designed over 39 ROVs, mainly for hydroacoustical, magnetic, and photographic work. FESTU's two 6,000-meter *Roby* submersibles were used to recover the flight recorded from the Korean Airline's Flight 007 in the Sea of Japan. IMTP has been developing AUVs since the 1970s for a variety of applications, ranging from ocean research to environmental monitoring. Two of their 6,000-meter class AUVs were used to locate and inspect two Soviet nuclear submarines sunk in the late 1980s. At the present time IMTP, in collaboration with the Autonomous Undersea Systems Institute in the USA, is working on a Solar Autonomous Underwater Vehicles (SAUV*)*, with support from the U.S. Office of Naval Research. The latter project tackles the major factor precluding long duration operations of AUVs; namely, short battery life.

The Russians have made impressive developments in a number of areas of **underwater acoustics**, particularly next generation acoustic source technology. U.S. and Russian researchers are collaborating in several projects in this area, including Acoustic Thermometry of Ocean Climate (ATOC). As part of the multi-national ATOC project, acoustic signals sent from Kauai have been recorded on a Russian surveillance array located at Kamchatka, Russia, for about two years. The efforts associated with ATOC and several other Russian and US projects were presented at a recent ONRIFO-sponsored workshop in experimental underwater acoustics, held in Nizhny-Novgorod, Russia.

The workshop included a brief tour of some of the facilities of the Institute of Applied Physics (IAP), including the Large Thermostratified Test Tank (LTTT). The LTTT was designed to study processes in the upper layer of the ocean, including internal and surface waves, interaction with shear waves, turbulence, hydrodynamics of submerged bodies, convection in a stratified liquid, and ocean surface optical and radio image formation. By means of thermal control systems, the LTTT is capable of producing a very pronounced and stable stratified layer that realistically simulates the thermal stratification of the upper ocean. The dimensions (length, width, depth) of the experimental tank are: 20 m, 4 m and 2 m, respectively. Figure 3 shows a picture of the tank.

Figure 3 The Large Thermostratified Test Tank of Russia's Institute of Applied Physics

The tank enables one to model and investigate:

- convection in a stratified liquid and its role in formation and sustaining of the scaled ocean thermocline;
- the parameters of internal and surface waves, their interaction with the shear flow, turbulence, and with each other;
- hydrodynamics of submerged bodies in the stratified flows and ship internal waves generation; shear flows and their influence on the thermocline,
- ocean surface optical and radio image formation; other problems of oceanology, shipbuilding and ecology.

The tank is equipped with:

- A thermostratification support system: two main refrigerators of total capacity approximately 94000 kcal/h; maintaining refrigerators of capacity approximately 33000 kcal/h and 6 delivery pumps of total capacity approximately 120 cubic m/h.
- Self-moving carriage (V=0.02-1.0 m/s);
- Rectangular (X, Y, Z) coordinate arrangement for precision temperature and velocity sensors;
- Internal wave maker (Frequency, 0.008 - 0.04 Hz), surface wave maker (Frequency, 1.5 - 3.5 Hz);
- shear flow inductor with the flow velocity in the outlet section (V=0.02-0.2 m/s);
- Information-measuring complex designed for registration of hydrodynamic processes in the bulk of thermostratified fluid and on its surface. It includes probes, analog-to-digital converters, PC and software.

Singapore

Although no larger than a dot on most world maps, Singapore is one of the major economies of the Asia-Pacific region. Its strength derives largely from its excellent knowledge and technology
infrastructure and its manufacturing prowess. It is a major oil-refining and petrochemical-manufacturing center and a strong player in electronics, especially semiconductor foundry products and contract manufacturing of telecommunications equipment. It is now positioning itself to be a regional hub for pharmaceuticals and life science products.

Singapore is also scaling up its R&D activities, and has committed $4 billion to promote and support R&D under its National Science and Technology Plan from 1996 to 2000. There are currently at least 13 research institutes and centers on which companies doing R&D can leverage their efforts. The National University of Singapore (NUS) is among the key R&D institutes. Of particular interest here is the Acoustic Research Laboratory (ARL) of NUS, whose key areas of research include ambient noise imaging, shallow water ambient noise, and marine mammal acoustics. ARL aspires to become the pre-eminent marine acoustics research laboratory in SE Asia and to attract international recognition and collaboration, with the long-term goal of providing Singapore with a self-contained and capable marine acoustics research resource. ARL is fairly new and small in size; however, much like Singapore itself, and NUS in particular, it is already an impressive force in the region in terms of caliber and productivity. A recent accomplishment of ARL is a "Pop-up Ambient Noise Data Acquisition System" (PANDA). The perennial bane to the existence of underwater acousticians is unwanted background noise (ambient noise). Of course, one man's "noise" is another man's "signal", hence ambient noise *per se* is often the quantity of interest. Whatever its ultimate use, effective and cheap methods to measure ambient noise are desirable. PANDA presents an effective approach to this problem. The PANDA system is a submerged data acquisition system for collecting acoustic data. The design is based on an IBM compatible PC. The system has a maximum sampling rate of 330 kHz and has maximum data storage of 1.2 Gbytes. PANDA is designed to be anchored to the sea floor with an acoustic release attached to it. All the electronics are contained inside a stainless steel pressure case. The pressure

case allows one hydrophone to be mounted to it and all connections are made via a shallow underwater connector. An important feature of this system is its flexible design. The system can be configured for multiple hydrophones, different sampling rates and higher data storage with minimal changes to the hardware and software. Figure 5 shows the PANDA being deployed.

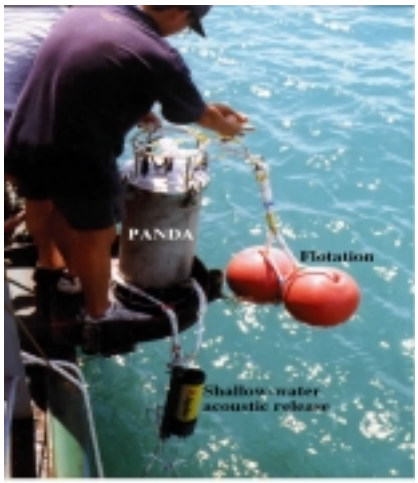

Figure 4 The Pop-up Ambient Noise Data Acquisition System of the National University of Singapore

India

The coastline of mainland India and its islands is about 7,500 kms, while its Exclusive Economic Zone (EEZ) is an incredible 2.02 million sq. km. These vast coastal and offshore environments shelter a population of about 200 million and support a wide variety of rich marine ecosystems, as well as diverse economic development activities. The coastline is also subjected to several billion cubic meters of domestic and industrial sewage, river-borne effluents, land wastes, fertilizer residues, pesticides and detergent residues. Understandably, therefore, research in the coastal zone leading to its sustainable development and durable utilization of its resources is a thrust area of India's activities. In 1981 the Government of India established the Department of Ocean Development to serve as the center for organizing, coordinating and promoting ocean development activities in the country. The National Institute of Oceanography (NIO) is one of the key organizations researching different aspects of coastal and open ocean environments. Set up in 1966 as an outcome of the International Indian Ocean Expedition it now has three regional centers at Mumbai, Kochi and Vishakhapatnam, besides its headquarters in Goa. The present staff strength of over 600 works with an annual budget of approximately $13 million (1999-2000). Among its primary coastal research areas are: Coastal circulation; Coastal engineering; Land-ocean interaction in the coastal zone (LOICZ); Coral reefs Mangroves; Pollution monitoring; Pollution remediation; Coastal management; Biodiversity; and Marine archaeology.

India is also making great strides in satellite oceanography, including the development of its own ocean-monitoring satellite, the indigenously built IRS-P4 (OCEANSAT). IRS-P4 is the first Indian satellite dedicated fully to ocean research. It was launched by the Indian Polar Satellite Launch Vehicle (PSLV) in June 1999 and placed in Polar sun-synchronous orbit at an altitude of 720 km. IRS-P4 has on board on Ocean Color Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR). OCM is a solid state camera operating in eight narrow spectral bands and can collect data on atmospheric aerosols and suspended sediments in the water. MSMR, which operates in four microwave frequencies, both in vertical and horizontal polarization, collects data on sea surface temperature, wind speed, cloud water content and water vapor content in the atmosphere above the ocean.

Malaysia

Increasing attention is being paid to marine science and technology in Malaysia, both at national institutions and as part of international efforts, particularly those involving the WESTPAC nations. At present much of Malaysia's oceanographic research efforts, including data collection, storage and dissemination, are scattered among a number of organizations in an as yet uncoordinated manner. However, approval has been given by the government for the establishment of an oceanographic directorate to coordinate oceanographic research in the country. Like other countries with relatively large coastlines, coastal protection is an especially important topic for Malaysia. Malaysia is experiencing an erosion threat to about 30% of its 4800 km shoreline. An interesting potential solution for coastal and riverside area erosion has been developed by the Coastal & Offshore Engineering Institute of the "Universiti Teknologi Malaysia." The "Sine-Slab" System is a patented pre-cast concrete product designed to accommodate nature's forces. It has several unique features. It can assure continuous construction and maximum stability via the 4-sided interlocking units. The effective keying, by means of hooklocking and slot-locking systems comprised of grooves and flanges, resists displacement and prevents erosion of the sub-soil. Sine-Slab has a hollow space structure that acts as a canal system to drain away surface water. This provides a natural buffer to dissipate and disperse the energy and impact of loading. Trapped sediments would allow vegetation growth that further strengthens the interlocking system. Weighing about 50 kg and designed for a maximum wave height of 2 m, the high strength concrete (grade 40) is able to distribute stress and resist elevation movement. The sinusoidal shape and perforation pattern of the Sine-Slab neutralize pressure from changing water levels and absorb energy from waves, current and turbulent water action. A simple and fast method of laying shortens the installation time.

The design, construction process and monitoring study of the performance of the Sine-Slab system were carried out for a pilot project at an eroding shoreline (120 m) at Tanjung Keling, Melaka. Visitors to the lost beach area can now walk on the slabs and at the same time still get to the water. This is a great advantage of Sine-Slab compared with others available in the market. Special emphasis of the research is given to the overall stability of the revetment system that consist of the toe protection, the Sine-Slab with the filter layer system and the run-up factors. The system was able to withstand wave attacks and hydraulic loading during seasonal storms and the highest astronomical tide experienced in a hundred years. Further close observations are being conducted for signs of structural and physical deterioration and damage, particularly at the location of expected sub-soil instability and at the cornered structures or turning angles. The Sine-Slab system is shown in Figure 5.

Figure 5 Two views of the Sine-Slab system developed by the "Universiti Teknologi Malaysia" to mitigate coastal erosion.

International Projects

Apart from the individual efforts of the various countries in this area, there are a number of international projects that foster collaboration on regional and global scales. These are based on the recognition that marine problems and opportunities do not often respect national boundaries, and that greater benefits may derive from multilateral collaborative projects than from national ones. WESTPAC, the Intergovernmental Oceanographic Commission's (IOC) Sub-Commission for the Western Pacific is a major sponsor and supporter of collaborations in this region. WESTPAC was established in 1989 to develop and coordinate regional marine scientific research programs, ocean observations and services based on the priority interests of the regional members. WESTPAC programs and projects cover a wide area, including:

- Ocean Dynamics and Climate
- Marine Pollution Research and Monitoring
- Ocean Science in Relation to Living Resources
- Ocean Science in Relation to Non-Living Resources
- Integrated Coastal Zone Management

One of the regional projects co-sponsored by WESTPAC is the North-East Asian Regional-Global Ocean Observing System (NEAR-GOOS), involving Japan, China, S. Korea, and Russia. At present, this focuses on the establishment of a system for the exchange of oceanographic data and products for the seas in the North East Asia region. Discussions are underway for a similar effort for the South East Asian region (SEA-GOOS), involving Malaysia, Thailand, Singapore, Vietnam, Cambodia, Myanmar, Indonesia, and the Philippines.

CONCLUSION

The paper has attempted to provide an overview of marine science and technology activities in the Asia Pacific region. Individually and in concert the nations of this region have made a long-term commitment to marine S&T as a necessary means to enhance their economic viability, social well being and national security. In addition to regional and global programs, several of the Asia-Pacific countries are engaged in bilateral activities in marine S&T.

In terms of economic strength and marine S&T infrastructure developments, Japan is clearly the dominant nation in the area. It is conceivable, indeed likely, that China and S. Korea will challenge Japan's dominance, certainly in some S&T areas. China, in particular, barring some unforeseen catastrophe, seems destined to be the major force in broad areas of science and technology. Several of the other countries in the region are engaged in noteworthy activities in particular areas, even though the scope and infrastructure of their marine S&T does not approach that of Japan, China, Russia, or S. Korea. It may be brash to say that the 21st Century will be an "Asia-Pacific century," but it does seem highly likely that the nations in this region will become major players in the area of marine S&T.